

Energy and economic profitability of the EMO concept

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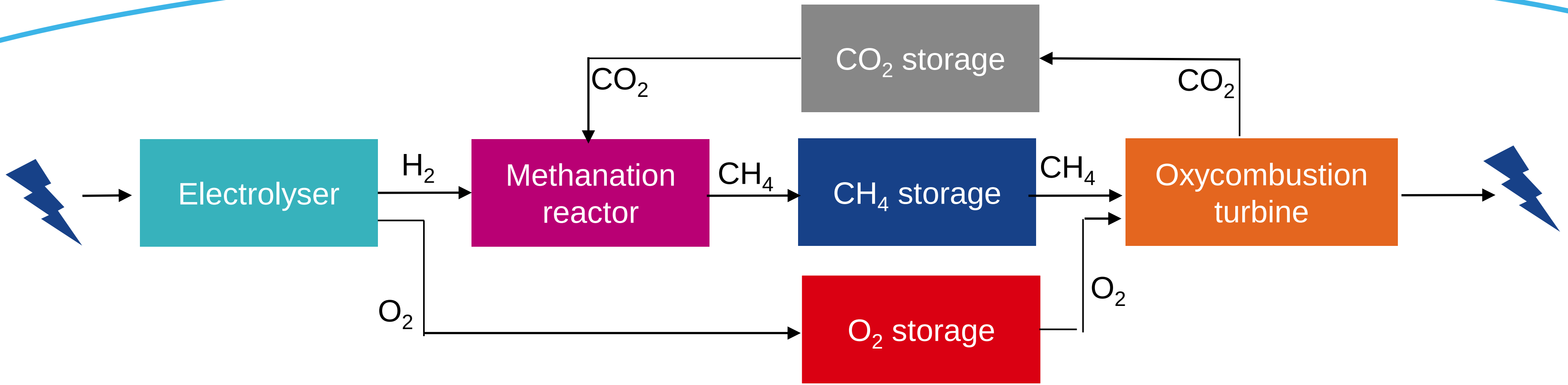
- Why does the cost structure matter ?
- Underground storage costs estimation
- Levelized cost of storage estimation
- Conclusion

Why does the cost structure matter?

Simplified EMO storage equipment: « energy transformation » or « storage »



Required equipments related to:

- the transformation capacity of the facility = Electrolysis – Methanation – Oxycombustion
- the storage capacity of the facility = 3 salt caverns

Simplified energy storage technological competition

GEOSTOCK ENTREPOSE

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Storage demand		
Power demand	1 MW	1 MW
Cycles	12h/12h 365 times per year	6 months / 6 months Once a year
→ Storage capacity demand	12 MWh	4 380 MWh

Technology CAPEX breakdown		
	« Transformation equipments »	« Storage equipments »
Techno 1	1000 €/kW	100 €/kWh
Techno 2	5000 €/kW	10 €/kWh

→ Total CAPEX involved	12 MWh case	4 380 MWh case
Techno 1	**2.2 M€**	**440 M€**
Techno 2	**5 M€**	**50 M€**

Reality is more complex

A comparison of competing storage solutions has to be done carefully. Many parameters come into play:

- The investment and operation costs for « power equipment »
  - high for power-to-gas solutions, including EMO
- The investment and operation costs for « storage equipment »
  - low for salt caverns
- The cost & frequency of replacement
  - high for batteries
- The storage efficiency
  - 30% for H_2 storage; 95% for Li-ion batteries
- The market(s) conditions
  - Currently, the « capacity market » pays more than the « energy markets »
- Last, projects can combine different techniques.
  - The HDF 140 MWh storage projet CEOG (*Centrale Électrique de l'Ouest Guyanais)* combines 20 MWh of batteries and 120 MWh of H_2 storage.

A usefull tool : Levelised Cost Of Storage (LCOS)
The breakeven selling price of the storage service

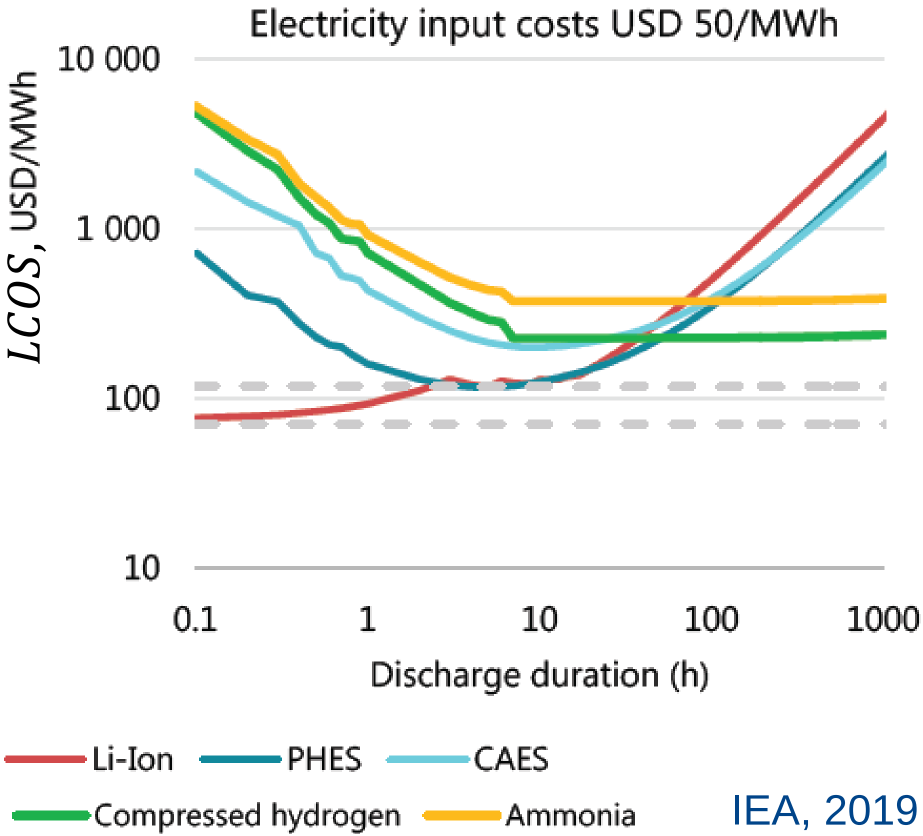
Lifetime of the facility (years)

$CAPEX(n) + OPEX_{fixed} + OPEX_{variable} \times P_{out}(n)$

$$LCOS = \frac{\sum_{n=1}^{N} \frac{Cost(n)}{(1+WACC)^n}}{\sum_{n=1}^{N} \frac{P_{out}(n)}{(1+WACC)^n}}$$

MWh produced during year n

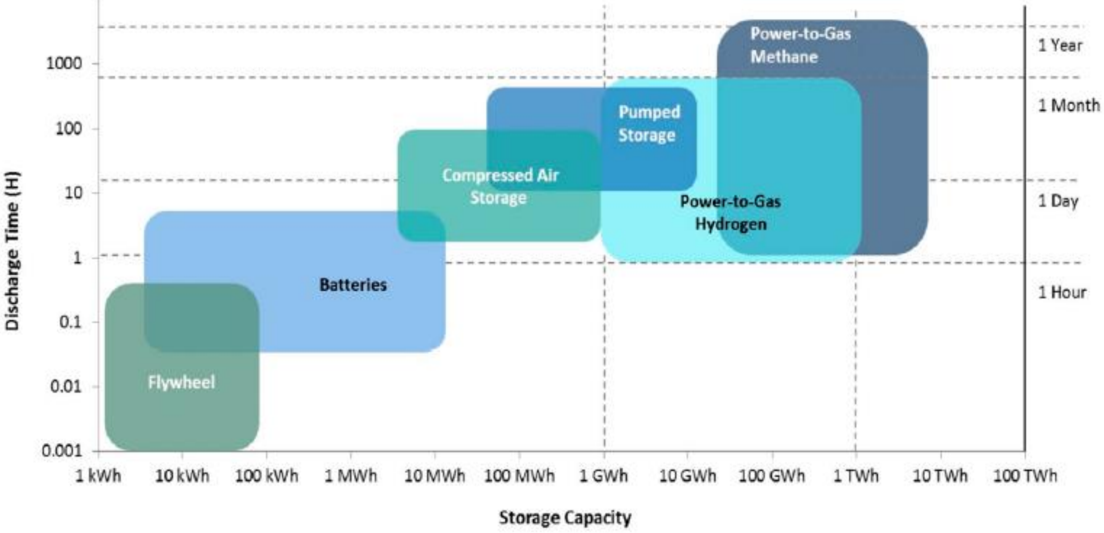
Weighted Average Cost of Capital



IEA, 2019

Cost structures and competing technologies are driving the cycles / storage range targetted by EMO storage

- Power to gas, including EMO storage, is in competition with other techniques



Moore & Shabani, 2015

What storage cycles should EMO consider ?

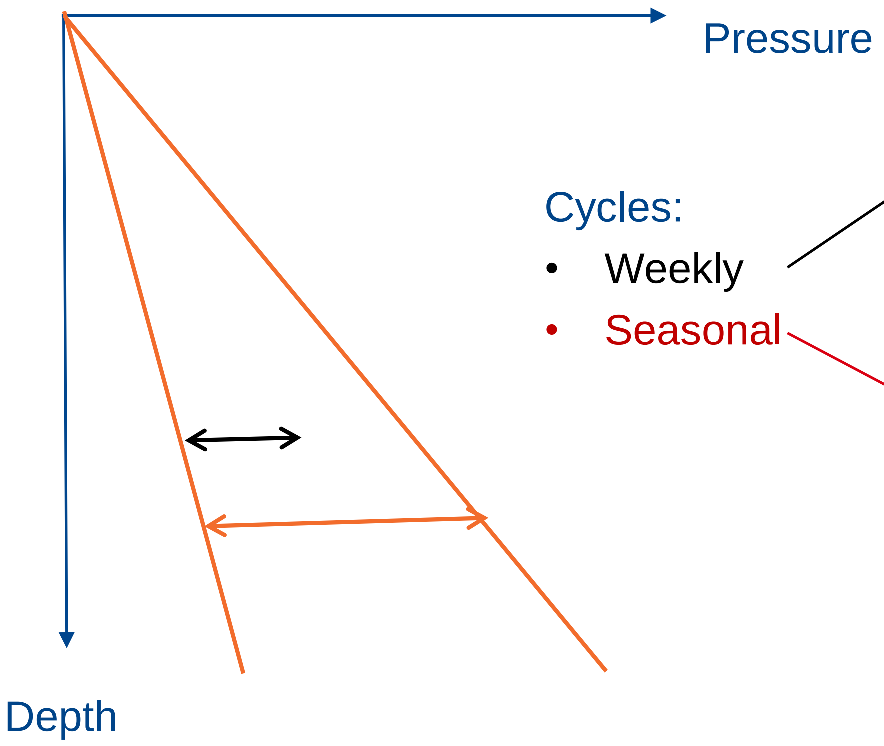
Is this technology competitive ?

- Underground storage cost estimate

- « Energy transformation », or surface equipments cost estimate
- → LCOS
- →Comparison with competing techniques
- → Definition of cycles

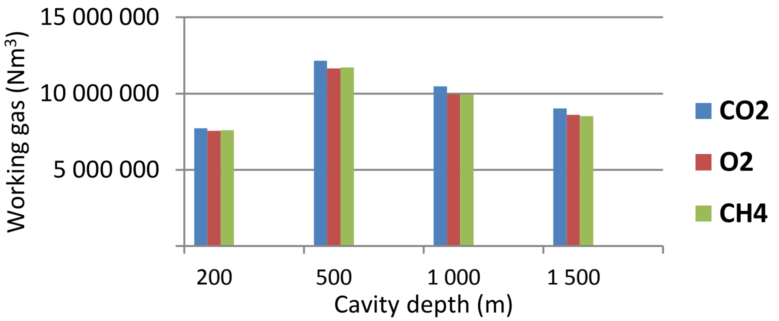
Underground costs estimation

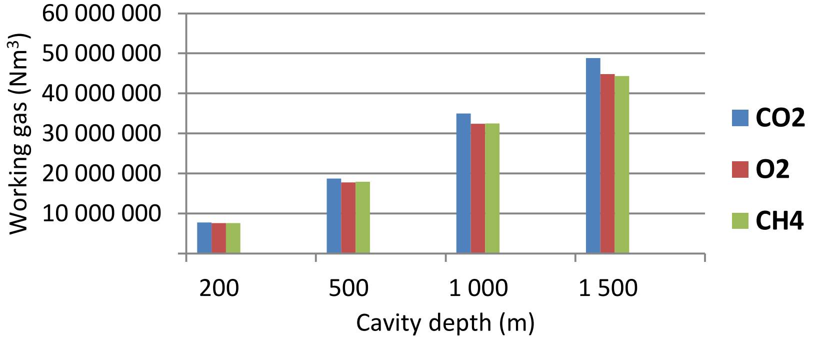
Nm^3 per m^3 : definition of an operating enveloppe and consideration of the storage cavern thermodynamics



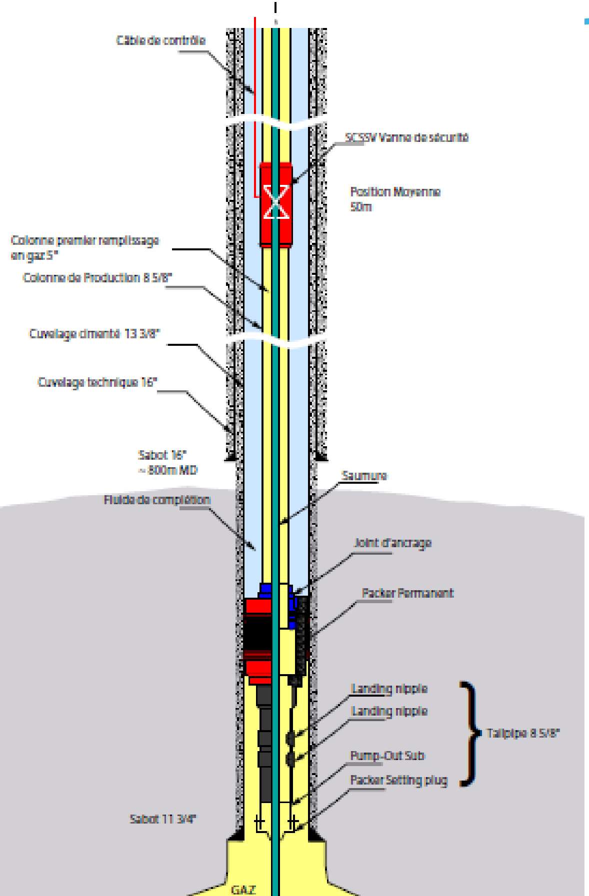
Cycles:

- Weekly
- Seasonal

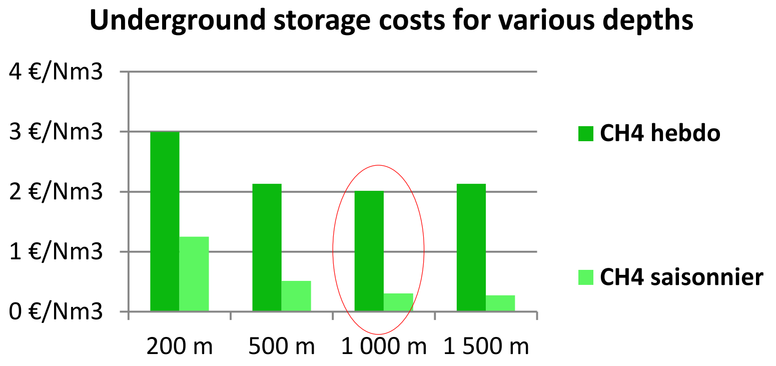




€/m^3 and per depth: Consideration of the well design, the number of wells, and the leaching cost.



- Proposition of a typical well architecture
- Cost estimate for various depths
- Adaptation of the number of wells to the acceptable flow rates



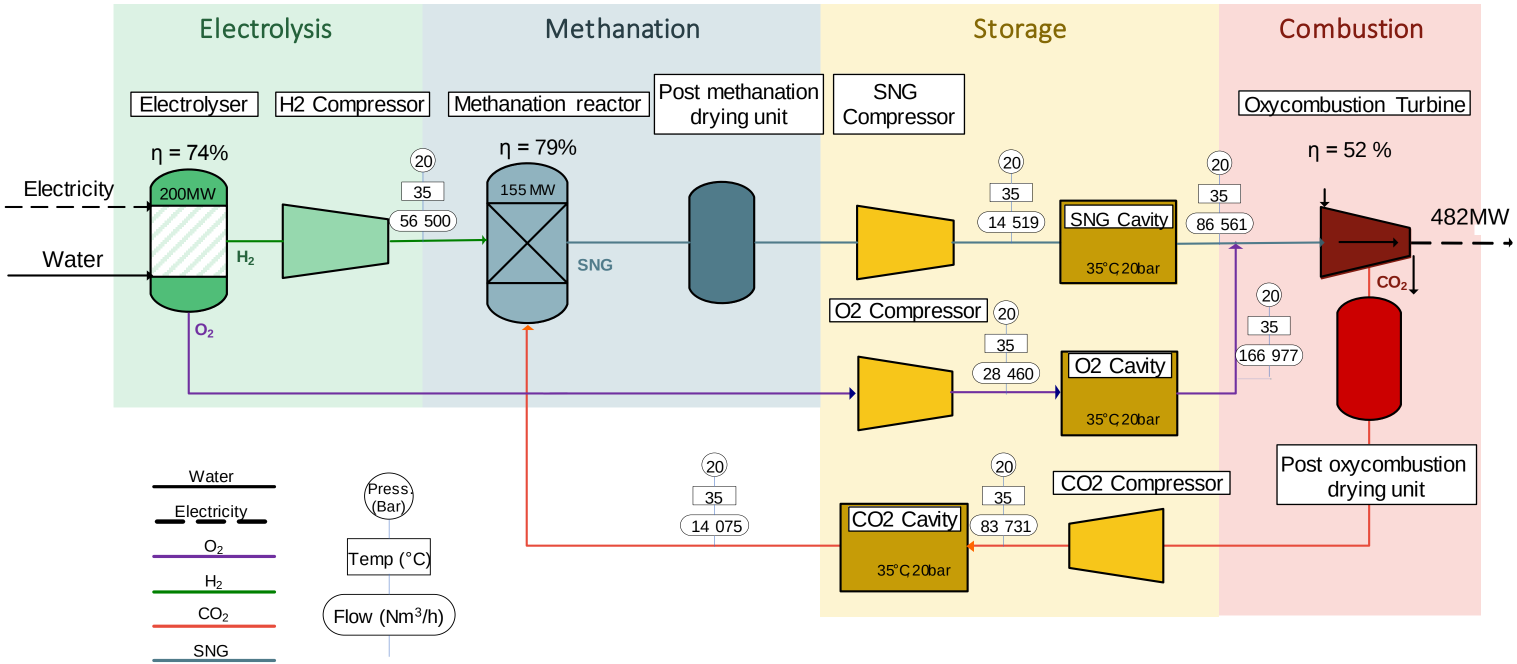
→ Cost of 0.4 €/Nm^3 or 2 €/Nm^3 of working gas for the weekly or seasonal storage.

→ 1000 m case. For all gases.

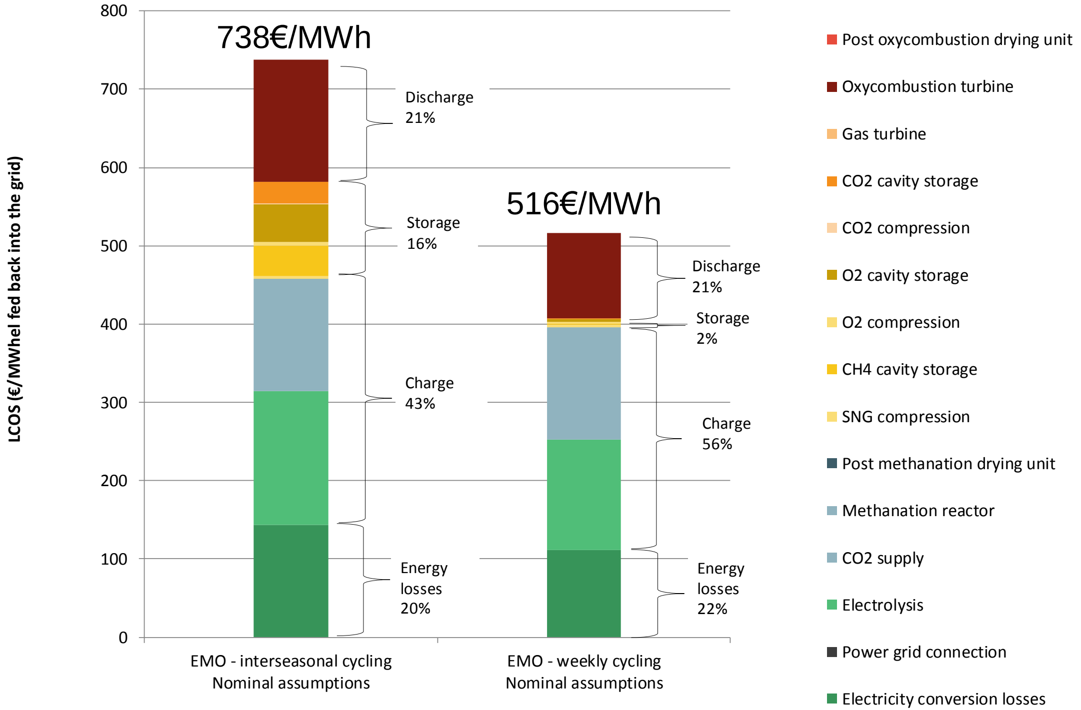
→ Suited to Manosque / Etrez / Hauterives / Tersanne conditions

Storage service cost estimation (LCOS)

The Levelized Cost of Storage (LCOS) accounts for the capital and operating costs of each component of the EMO process



Charging and discharging account for the majority of EMO's LCOS in both interseasonal and weekly cycling scenarios



For weekly storage, EMO competes against proven technologies

EMO

- Electrolysis Methanation
- Cavity storage (CH_4, CO_2, O_2)
- Oxycombustion

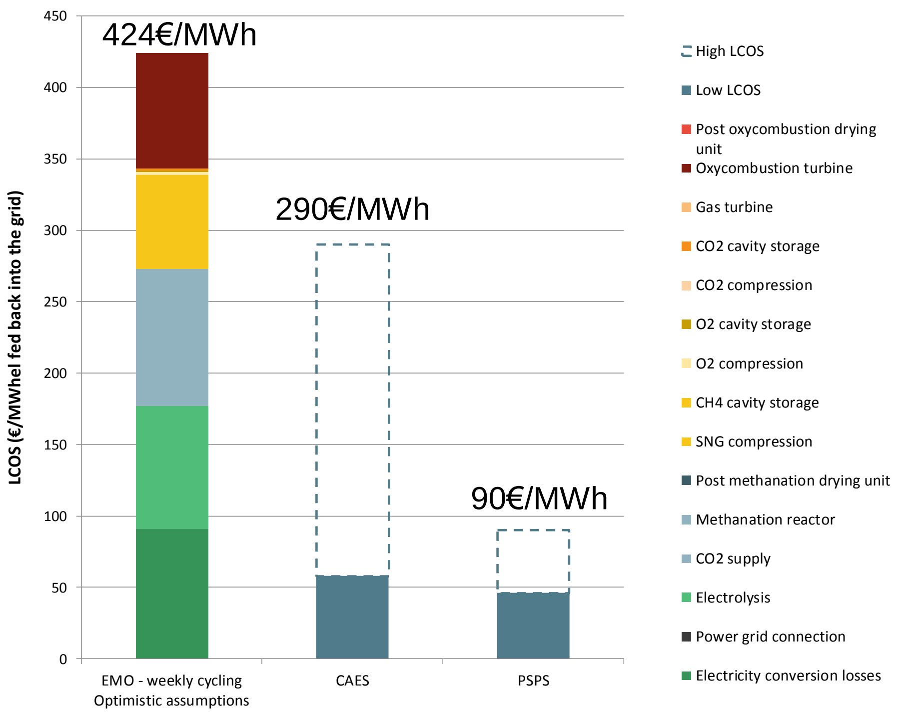
Pumped Storage Power Stations

- Water pumping
- Water storage in dam
- Water turbine

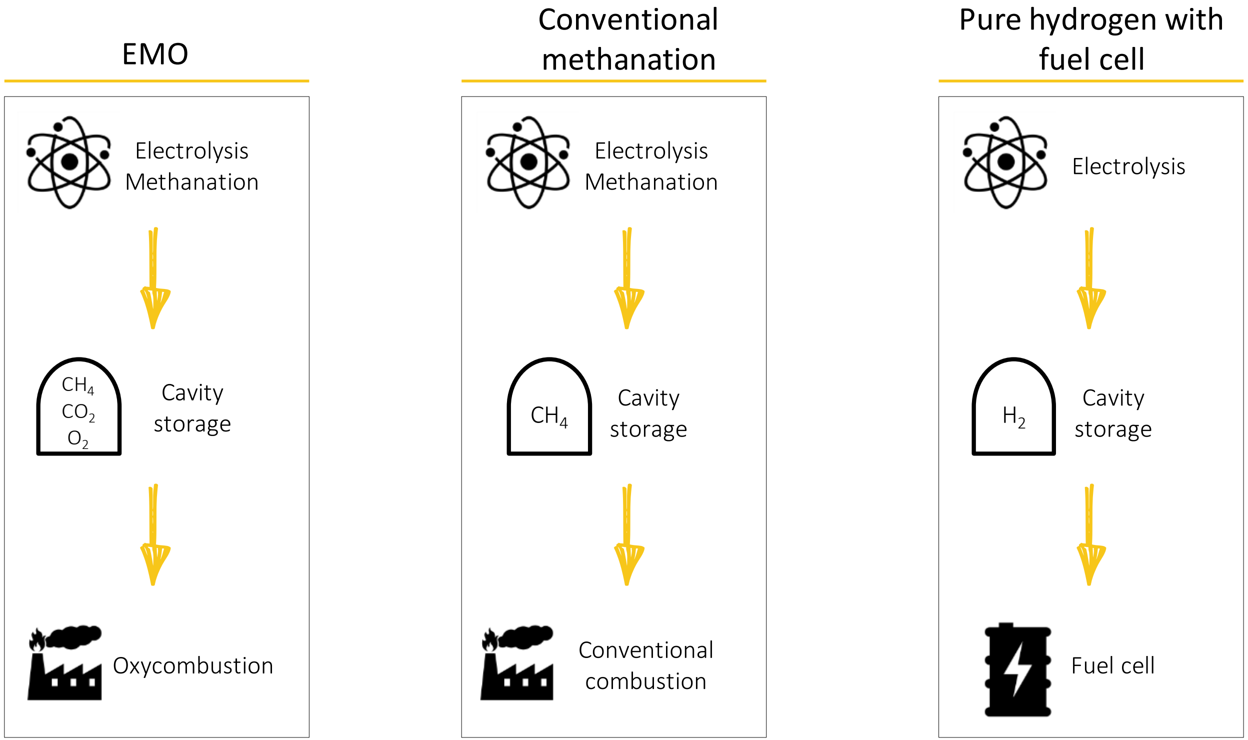
Compressed Air Energy Storage

- Air compression
- Cavity storage (Air)
- Air decompression

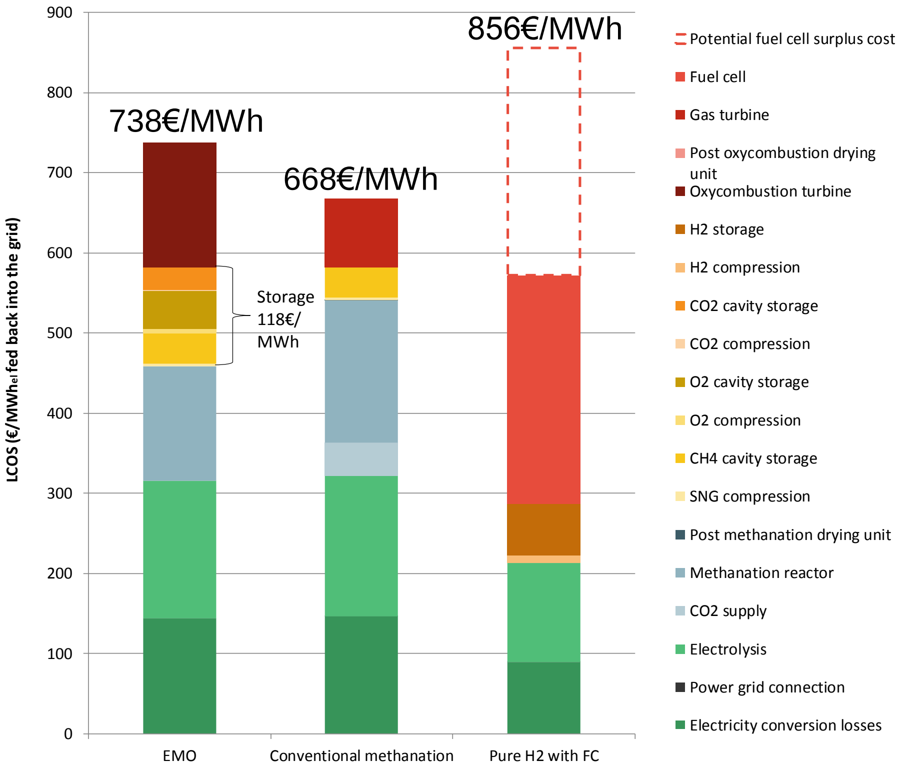
EMO is not competitive against CAES and pumped storage (PSPS)



For interseasonal storage, EMO competes against other power-to-gas-to-power technologies



EMO falls within a similar cost range as other power-to-gas-to-power technologies, with potential for further cost reductions



Conclusions

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Power-to-gas is adapted to interseasonal storage

- Power-to-gas cannot compete with PSPS for weekly storage demand
- Power-to-gas is costly, but it is the only suitable technology for interseasonal storage

EMO system must be able to undergo short times of discharge

- Charging assets and cavities must handle short to long charging periods (6 hours to 8 days)
- Discharging assets and cavities must handle very short to moderate periods (6 hours to 8 days)

Thank you for your attention !

Acknowledgments:

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